ITC DISCUSSION DOCUMENT ON DIGITAL TELEVISION

Introduction

1. Digital television transmitted terrestrially and by satellite offers the prospect of a considerable increase in the number of programme channels available or in the technical quality of the signals, or some combination of the two. However, with regard especially to terrestrial television, there are several difficulties which first have to be resolved, and the ITC is therefore involved in a major technical research programme to look into the capabilities of digital terrestrial television in the UK. This is the 'SPECTRE' project being carried out for the ITC under contract by National Transcommunications Limited (NTL). Results from frequency planning studies and field trial experiments are now becoming available, and these are being coordinated with other European organisations involved in related research projects. In the US and Canada, work already in hand is likely to result in agreement on a North American standard for digital terrestrial television within the next two years. Direct-to-home digital television transmissions by satellite are likely to start in North America and in Europe before the end of 1995.

2. The ITC believes that it is important for there to be a policy debate about the development of digital television in the UK in advance of the first systems being implemented in the market. This discussion document is being published as a contribution to this debate, with a particular emphasis on terrestrial transmission. Anyone wishing to comment on it is asked to write to The Secretary to the ITC by the end of September 1993.

Technical Background

3. The conversion of television signals to a digital format is already common within many modern studios and television receivers. Digital techniques are increasingly used also in the telecommunications links which connect studios with each other and with transmitters. The phrase "digital television" is used here, however, to apply to the broadcasting of television services direct to the home. The system currently employed to do this is an analogue system known as PAL, which was introduced in the UK in 1967.

4. Digital television broadcasting encompasses a number of separate processes. One of these is digital modulation and transmission. This means the transmission of television programmes (vision, sound and any associated additional information) as digital information (ie, a stream of binary digits, or "ones" or "zeros"). This technique can provide a consistent high quality of reception (which is effectively free

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of noise or interference effects) throughout the service area and with a variable quality of domestic aerial installation. A disadvantage is that when digital transmission systems fail (for example, at the edge of the service area or due to poor reception conditions), they tend not simply to provide a poorer quality of picture or sound but to fail completely. Another important process is digital compression. Television pictures before compression constitute a very large amount of digital information. Compression works by using computer analysis techniques to extract from the television pictures (and also sound signals) only the minimum amount of information necessary to reconstruct them in an intelligent new receiver. This "unpredictable" information represents only a small fraction of that contained in the original digital representation of the signals and forms the basis of the transmitted signal. However the more a television signal is compressed, the more likely it is that some complex scenes which occur occasionally within programmes will suffer a loss of picture quality.

5. By combining digital modulation and transmission with compression, digital television broadcasting can make much more effective use of the frequency channels which are available than PAL. This increase in effectiveness can be exploited within the same frequency capacity by providing more programme services, improved technical quality or a combination of the two. In determining the number of programme services which can be accommodated within a digital channel, there are five variables to be considered:

- **The type of channel available.** This is determined principally by the bandwidth and transmission power. Satellite and terrestrial channels differ significantly in this respect.

- **The coverage area required.**

- **The type of receiving conditions considered.** There is a significant difference, for example, between reception on a fixed satellite dish or high quality roof top aerial and reception on a small portable aerial.

- **The type of modulation and transmission techniques used.** These will determine how much digital capacity for carrying programmes can be conveyed through a particular channel. Although many different techniques have been developed, a general rule applies: the higher the capacity to be conveyed, the less rugged the transmission (ie, the smaller the coverage area and/or the better the necessary receiving conditions).

- **The level of picture quality required.** There are two elements of this. The first is the source quality (eg. 625 lines for conventional television or 1250 lines for high definition television) and the second is the amount of degradation, introduced by the compression process, which is considered to be acceptable. Setting requirements for both of these will determine the digital capacity needed to convey a particular quality of programme service.

(Other factors contributing to the capacity required will include the number and quality of sound channels employed and the amount of ancillary data needed - eg. for conditional access purposes).

6. These variables are considered in more detail, and some preliminary calculations of channel availability are made, in the Technical Annex attached to this document. Some of the major points to note from the Annex are:

- There are a large number of satellite channels available for digital transmission and each of these channels would be technically capable of carrying, for example, one full quality HDTV service or around eight services of PAL-equivalent quality. Hundreds of additional programme services could therefore be provided in a relatively straightforward way across most of Europe by using satellite digital technology.

- For terrestrial channels an important distinction is to be drawn between the potential for the introduction of digital services alongside existing PAL transmissions, and the long-term possibility of having digital transmission only in the UHF spectrum allocated to broadcasting.

- In the first of these cases, the availability of digital channels is patchy across the UK (and even more so across Europe) with some areas having more than 20 digital channels available and others having less than three. Furthermore each of these channels would have a restricted capacity and would not generally be able to provide full HDTV quality with a coverage area similar to that provided by existing PAL services.

- In the second of these cases (the long-term digital-only case) a significant improvement in spectrum efficiency could be provided enabling many more digital channels to be available on a uniform basis across the UK. Each channel would probably be capable of providing HDTV quality with full coverage. Nevertheless even in this case the terrestrial medium would fall short of satellite in its ability to offer very large numbers of programme services across a wide geographic area.

Introduction Strategies

7. In terms of terrestrial television the outlook for digital transmission depends heavily on whether and for how long the existing PAL transmissions are to continue. If these transmissions could be replaced by digital transmissions then the gain in terms of the efficient use of the frequency spectrum would be very considerable. There are three main uses to which this gain could be put, although some alternatives and combinations are, of course, possible.

First, many more programme services (perhaps of the order of 100, see Technical Annex) could be transmitted with a similar technical quality to the existing PAL transmissions. This could take the form of wholly new programme services, if sufficient funding could be found, but need not necessarily take that form. For example, the same programme service could be offered on two channels but differently scheduled in each case - with, say, the emphasis given to light entertainment in peak time on one channel and current affairs in peak time on the other. Alternatively, for sporting events, where more than one camera position is in use, the output of each camera could be broadcast on a separate channel so that the viewer could decide which one to watch instead of the programme director making this choice for him. Also, sub-regional news material could be transmitted to the whole region using separate channels, thus allowing viewers to choose which sub-region is of most interest to them.

Secondly, an increased number, but lower than the above (of the order of 10-15) of terrestrial channels could be broadcast in HDTV. One possibility is that such channels need not broadcast HDTV all the time, but could carry a number of standard definition programmes at some times of the day.

Thirdly, frequency spectrum currently used for broadcasting could be released to satisfy other demands, eg, for mobile communications.

8. The gains in terms of the efficient use of spectrum which could be obtained from the exclusive use of digital transmission for the existing terrestrial services are so great that it is hard to see how the continuation of PAL transmissions could be justified in the longer term. However, a policy of terminating PAL transmissions raises some major issues about the configuration of the digital terrestrial television broadcasting which would follow it and the transitional problems which would arise.

9. Account needs to be taken of the fact that the 10 year licences for Channels 3 and 4 (and for Additional Services) have only just begun and their terms cannot be unilaterally altered during their lifetime. There would in any case need to be a very substantial notice period, of at least 10 years, before PAL transmissions could be terminated. Viewers have made a considerable investment in PAL television receivers and VCRs, many of which have a long life left in them. Manufacturers also have to produce and market the necessary digital receiving equipment. Notice could not be given until the substantial technical problems concerning the terrestrial transmission of digital signals (of a kind which do not arise in relation to satellite broadcasting), have been resolved and until there is agreement on a digital standard, preferably for Europe as a whole.

10. There would be substantial difficulties however, about relying simply on a long notice period before switching off PAL transmissions. The danger would be that viewers, broadcasters and programme makers would wait until the last possible moment before making the change to digital television, leading around that time to the possibility of confusion and frustration, shortages of equipment and a generally disorderly transition.

11. What is needed, in addition to a long notice period, is an opportunity and incentive for digital transmission to be introduced gradually and taken up by viewers over a number of years. With this in mind, three possible strategic approaches towards introducing digital terrestrial television are described in the following models.

Model 1: Simulcasting

12. Under this model existing terrestrial broadcasters (ie, Channel 3, Channel 4, S4C and the BBC and - if implemented on an analogue basis - Channel 5) would be given the option of broadcasting their service in parallel on a digital channel during a transition or "simulcasting" phase before the cessation of PAL transmissions. In the case of Channels 3, 4 and 5 we believe that the current legislation and licensing framework would enable this to be done. The ITC could amend the existing licences by adding digital frequencies to the coverage requirements. This would be done by agreement with the licensees. Each licence would continue, however, to be for the provision of a single service, and so the use of a digital channel to provide an additional and significantly different programme service (or range of services) would not be permissible under this route without the introduction of new legislation. After the end of the existing licence period the option to accept a simulcasting obligation could, under new legislation, be made a requirement. During the simulcasting period the receiver industry would phase out PAL-only receivers and make available to the public dual-standard (or later digital-only) receivers as well as "set-top boxes" to enable the reception of digital signals on existing sets.

13. During this period there would need to be an incentive for viewers to purchase digital receiving equipment and shift their viewing towards the digital service. No such incentive would exist if, throughout the transitional period, simulcasting involved only the transmission in both PAL and digital of an identical programme service to the same technical standards. In these circumstances simulcasting would achieve no more than a notice period: its costs, and the constraints it would impose on the early introduction of wholly new services, could not be justified.

14. In order to create an incentive in favour of digital transmission it would probably be necessary to allow some distinction in the two programme services, with more attractive programming being introduced on the digital service. It would probably also be necessary to ensure that the digital service was offered in a different format, (ie, a 16:9 aspect ratio) and to a higher picture quality. A problem with the first of these incentives is that it would require new legislation. A problem with the second incentive is that full HDTV quality is technically difficult to achieve in any transition period (due to the "taboo channel" limitations discussed in the Technical Annex) and so an extended definition quality (ie, based on current 625 line studio standards but employing the 16:9 aspect ratio) may have to suffice. The ITC has recently demonstrated digital terrestrial television transmission using this quality. A common view was that its effect was almost indistinguishable from that of HDTV using current display technology and under normal viewing conditions. The benefits of HDTV may, therefore, only be worthwhile when a new consumer display technology (flat-screen) is developed, and this is itself a number of years away. However, the extended definition quality which can be provided digitally is not very different from that which will be able to be provided on existing analogue channels and in the 16:9 aspect ratio using the PALplus system from around 1995. The technical incentive of digital in a transition period might therefore relate more to its reception properties (clean reception all the way to the edge of the service area, even with a variable quality of domestic aerial installation) than to its core picture quality capabilities.

15. The simulcast model has been adopted by the Federal Communications Commission (FCC) in the US for the terrestrial introduction of "Advanced Television" (this is a phrase used in the US primarily to describe HDTV). The proposal there is to begin the process of transition from NTSC (the current US transmission standard) to digital TV once a new digital standard is agreed (expected to be in 1994 or 1995). Existing broadcasters would from that time be given first option on applying for a digital frequency in their locality within a period of three years. Those who applied for a frequency would then have to implement a digital service within six years of the initial standards-agreement date. The existing NTSC channel would be removed at the 15 year point. (These dates are subject to review as the process develops.) The requirement would be to simulcast on the digital channel, but with some relaxation to allow new programming (to stimulate receiver sales) within the first few years of service operation.

16. The frequency planning situation in the US is simpler than that in Europe, and this makes the technical implementation of a simulcast strategy more straightforward. In the US, the coverage available for simulcast digital services is not quite the same as that for the existing services, but reasonable coverage is available in the great majority of US cities for a digital simulcast version of all existing high power services. The system currently being developed to be put forward for standards selection in the US is generally less ambitious from a technical point of view than some of those being considered in

Europe, and this is partly because of the simpler frequency planning environment and partly because of the short timescales for standardisation. The picture quality to be provided corresponds roughly to the second level considered in the Technical Annex, ie, HDTV quality with some distortion on critical scenes. Consideration is also being given in the US to multi-programme possibilities, using a lower technical quality, for the simulcast digital channel during some periods of the day.

17. The simulcast model therefore already has some currency in the worldwide digital TV debate. It is also analogous to the route adopted in the period 1967-1985 for the successful transition in the UK from 405-line monochrome VHF to 625-line colour UHF television and to the model being considered now in the UK for the introduction of Digital Audio Broadcasting (DAB).

18. A major technical challenge with the simulcast concept for the UK is the problem of patchy coverage (see Technical Annex). Ideally simulcasting requires a uniform availability of digital channels, whereas what is actually available for the transition phase is rather varied from one place to another. In some areas, currently expected to represent 15-20 per cent of the UK population, there do not appear to be the necessary number of digital channels available for simulcasting. The implication of differential coverage between analogue (PAL) and digital versions of existing services during a simulcasting phase would be that in those areas which were able to receive a PAL service but not a digital one, viewers would be deprived of the improved technical standards or different programming provided by the digital service during the simulcasting period, although it would be possible to provide full digital coverage immediately after PAL transmissions were switched off. It would clearly be desirable to keep the differences between PAL and digital coverage during any simulcasting period as small as practicable.

19. Finding a solution to this problem is a challenge being considered in the current R&D work. Options include:

- Develop even lower power digital transmission systems so that more channels can be squeezed in.

- Adopt a policy of implementing simulcast for some, not all, of the existing services in the affected area.

- Adopt a policy of implementing simulcast with a lower picture quality in the affected areas by, for example, in the most extreme cases carrying all the existing programme services within a single digital frequency channel. (This would however leave the transmission of more attractive programmes on the digital service with the task of offsetting lower technical standards and providing viewers with a net incentive to obtain and watch digital transmissions.)

- Identify other frequencies which might be made available.

20. In the context of the last of these options, two possible frequencies which have a particular significance are UHF channels 35 and 37. These are not currently used for broadcasting in the UK, but they are set aside for the implementation of Channel 5. The ITC is planning to issue shortly a separate consultation document on the future of Channel 5. The ITC has also commissioned a frequency planning study to investigate the improvement in digital coverage which might be achieved if channels 35 and 37 were available for that purpose. The study will also consider the extent of any VCR interference problem which might arise if channels 35 and 37 were used digitally.

Model 2: New Services

21. This model is based on the premise that any new digital channels should be made available to any prospective users, with none being set aside for simulcasting. Existing broadcasters who wished to simulcast would have to bid like anyone else for the necessary digital channels. An allocative mechanism would clearly be needed for the channels. It is conceivable that the local delivery provisions of the existing legislation could be used for this purpose, but these were drafted as a technology-neutral replacement for cable licences and are not ideally suited to the introduction of digital UHF services. The existing legislation for Channel 5 is another option, although this relates only to a single service, and one which carries specific programme obligations. New legislation would therefore probably be required.

22. A benefit for the public of the new services route would be the possibility for an early availability of a number of new services terrestrially, although a new receiver or a "set-top box" would be required in order to receive them. It could be argued that the availability of new services would provide a stronger incentive to viewers to buy the necessary receiving equipment than would the provision of an improved technical quality and only limited programme differences between the digital and PAL transmissions under the simulcast route.

23. However, the new services model also has some difficulties. A two-tier system of programme services would be established terrestrially - with existing services broadcasting in PAL and new services broadcasting digitally. Dual-standard receivers would provide a different level of performance from one type of service to another depending upon the technical standards to which the digital service was broadcast. Even if the digital and PAL services provided a similar core picture quality, reception quality would differ across the service area. This situation exists already to a certain extent when considering the existing terrestrial services alongside the new competing services on satellite. However, since satellite receivers are already in the market, providing the opportunity for an increasing number of new services to be introduced, the need to bring in a new technology terrestrially purely to open up some further new channels may not seem great. On the other hand, terrestrial broadcasting is particularly well suited to the provision of regional or more local programme services.

24. As discussed earlier, the clearest form of long-term benefit from digital transmission would be provided if the existing PAL transmissions could be phased out in the future. The setting-up of a system in which existing services using exclusively PAL were competing with new digital services would make it difficult to achieve this position in a fair and equitable way.

25. If the new services model were regarded as an alternative to Channel 5, the frequencies currently set aside for Channel 5 could be used for new digital services providing more programme channels and better national coverage, and with a much reduced VCR interference problem. However, a set-top box or new receiver would be required, whereas the transmission of Channel 5 in PAL would allow the signal to be received on current TV sets (although in some cases an additional aerial would be required).

Model 3: Simulcasting and New Services Combined

26. The third model combines simulcasting with the availability of new digital services. It is essentially a restatement of the simulcasting model, but recognising that in many areas of the UK more digital terrestrial channels are available than are necessary to fulfil simulcasting requirements. Under this third model these additional channels would not lie fallow but would be made available for new services as quickly as possible.

27. The advantage of the simulcast-plus-new-services model is that it combines so far as possible the benefits of the two approaches. Simulcasting could provide a backbone of services which would enable a transition to spectrum-efficient all-digital transmission to take place, while the availability of new services would (at least in most areas) provide an additional incentive for viewers to purchase the necessary receiving equipment. In the face of this option, there seems to be no reason to consider separately the model of simulcast alone (with no new services), and effectively the three models discussed so far can be considered as only two as far as policy options are concerned.

Other Models for the Introduction of Digital Television.

28. An alternative model to the simulcasting approach outlined here would be simulcasting-by-satellite. Under such a model the long-term objective would be to clear the terrestrial UHF frequencies of television services altogether, leaving the media of satellite and cable to provide all television services to the home. During a simulcasting period the existing services would be simulcast by satellite, and provided by cable where this was available, so that all terrestrial TV receiving equipment would be phased out prior to the switching off of PAL transmissions.

29. It could be argued that this approach would deliver even more spectrum efficiency than the terrestrial-simulcasting model, but some significant drawbacks of relying on the satellite distribution of current services include:

- Lack of regionally specific programme provision (although each regional variation might in principle be reproduced on a separate satellite channel).
- Lack of reception on portable receivers with simple aerials.
- Lack of universal coverage (ie, more homes are served by terrestrial television than are capable of receiving a satellite signal.)

30. Another model would be a status quo approach. Under this model there would be no digital terrestrial television developments at all, and all digital advances would take place only on satellite or cable. There would be no promise of greater spectrum efficiency in the long-term future (unless terrestrial services were to slowly "wither on the vine"). Although this might provide a simpler and less disruptive outlook for viewers who remained content to receive only the existing terrestrial services, a strategy of this kind would be seen by many as defeatist and unacceptable.

Timescales

31. As stated earlier, direct-to-home digital services by satellite might start in Europe in 1995. It might be technically feasible for some cable services to meet a similar timescale. The ITC believes that any introduction of digital terrestrial services will occur later than this, not least because the technical development and the market approach are less clear at this stage. An important factor in the timescale equation, however, will be the establishment of a viable introduction strategy. If a way forward is established quickly, and a legislative path is identified, then we believe that the introduction of digital terrestrial television need not lag very significantly behind satellite or cable.

32. The wider European dimension is also relevant to the timescale issue. The achievement of a coordinated European approach may take longer than if the issues are considered for one country alone, but on the other hand European standards would lead to larger markets for receiving equipment.

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Questions

33. Of the models considered in this document it appears to the ITC at present that the balance of advantages for a digital terrestrial television introduction strategy would lie with Model 3, ie, simulcasting-plus-new-services. There may, however, be further considerations to take into account, not least because of the current pace of technical developments in the digital television field. The ITC would welcome comments on the ideas and proposals set out in this document, and in particular on the following questions:

Q1 **Are there additional factors to be taken into account when considering strategies? Is the simulcasting-plus-new-services approach to be preferred, or are there greater advantages in other ways of proceeding?**

Q2 **What is the economic case for the introduction of digital terrestrial television? Who would benefit and how?**

Q3 **Taking account of technical feasibility, what would be an appropriate timescale for the introduction of digital terrestrial television?**

Q4 **Taking account of the options discussed in paragraph 7, how should the long term benefits of digital terrestrial television be used?**

Q5 **How important is it for any UK strategy for the introduction of digital terrestrial television to be coordinated with that of other European countries? To what extent would such coordination justify a delay in implementation?**

Q6 **In what ways is it likely that parallel developments in North America (and possibly in Japan) will (or should) influence the development of digital terrestrial television the UK or the rest of Europe?**

Q7 **How important is HDTV likely to be in the future development of television services and on what timescale? What would be the most effective way of introducing it?**

34. As stated in paragraph 2, any comments are to be sent to the Secretary to the ITC by the end of September 1993. The ITC will respect the confidentiality of any responses received, where this is requested, although unattributed reference to the points made may be used in any further discussion or policy document and in any summary of responses which the ITC might publish.

TECHNICAL ANNEX

Digital Channel Capacity and Availability

Compression and Picture Quality

1. Based on the current state of the art (as considered, for example, in the ISO/IEC Motion Picture Experts Group (MPEG)), some examples of the picture quality which is likely to be available from a particular compressed digital capacity are as follows (the units used to express digital capacity are millions of binary digits per second - Mbit/s):

(i) Studio high definition (HDTV) quality (1,250 lines) with no perceptible degradations - 40 Mbit/s

(ii) HDTV quality with some distortion on critical scenes - 20 Mbit/s

(iii) 625 line studio-quality with no perceptible degradation - 10 Mbit/s

(iv) 625 line quality with some distortion on critical scenes - 5 Mbit/s

(v) Reduced quality (312 line) with no perceptible degradations - 2.5 Mbit/s

(vi) Reduced quality (312 line) with some distortion on critical scenes - 1.2 Mbit/s

As a guide for comparison, the fourth example here (5 Mbit/s) is often considered as roughly equivalent in quality to PAL and the sixth (1.2 Mbit/s) as roughly equivalent to home video (VHS) quality (although the nature of the distortions which occur in the digital and the analogue systems is very different in both cases). As an indication of the amount of compression which is implied in the above figures, an initial representation of 625 line studio-quality pictures in digital form takes up around 200 Mbit/s and so with no picture degradation the compression factor is around 20:1, while with some picture distortion on critical scenes a compression factor of around 40:1 can be achieved. On the sound side, the capacity required for a compressed high quality digital stereo signal is around 0.25 Mbit/s.

Satellite Channels

2. The most straightforward case to consider in terms of digital capacity is a satellite channel. This is because reception occurs via a fixed dish under relatively predictable conditions. A single channel of the type currently used to carry one PAL service for direct-to-home transmission can convey, using a suitable modulation and transmission system, a digital capacity for programme services of around 45 Mbit/s for the same coverage and receiver dish size as that associated with current services.

Allowing for sound and for other information (such as conditional access data), and using the figures from the previous paragraph, this means that one digital satellite channel might be used to carry:

- one full quality HDTV service, or
- four full studio-quality 625 line services, or
- eight PAL-equivalent services, or
- around thirty VHS-equivalent services.

Given that a single satellite (of the Astra type, for example) can accommodate 18 digital transponders (channels), this means that 144 PAL-equivalent programme services (or as many as 500 VHS-equivalent services) might be provided by a single satellite across most of Europe. The actual numbers are not necessarily accurate here, since the precise channel availability will depend on the details of the final specifications which are currently being developed for a European digital satellite system. But the main point to note is that digital satellite techniques offer the prospect of very large numbers of programme services across a wide coverage area from only a small number of satellites. Digital satellite services providing such features as near-video-on-demand (which employs a number of programme channels to convey time-shifted versions of the same feature film or other programme source) are currently planned to start in Europe in 1995. Similar developments are taking place in the US, with an even shorter timescale, and also in other parts of the world such as South East Asia.

Terrestrial Channels

3. For digital terrestrial television the channel availability and quality calculations are less straightforward. This is because a variety of reception conditions are possible (via a fixed roof-top aerial or via a set-top portable aerial, for example) and because the nature of the channels available will depend on the congestion of frequency use by the current PAL services which are in the proximity of any new digital transmitter. In broad terms it is possible to consider three types of reception condition (fixed, portable and mobile) and two types of transmission channel ("taboo" channels, or those which have to coexist with nearby PAL transmissions using related frequencies, and "clear" channels, which do not have to coexist with nearby PAL services and therefore have fewer technical constraints and can operate with increased power). During any period when digital and PAL terrestrial services coexist using the same frequency band, only taboo channels will be available, while if it proves possible to remove all PAL transmissions (or to identify new frequencies which are not already used for PAL) then technically superior clear channels can be used.

4. Taboo channels are more constrained than clear channels in the digital capacity which they can accommodate. For either type of channel, the greater the digital capacity which is

accommodated, the more difficult it is to provide satisfactory reception (especially for portable or mobile conditions). Some illustrative and tentative figures are given in the following table in order to try to quantify these trade-offs.

Type of Terrestrial Channel	**Digital Capacity Accommodated**	**Reception and Coverage Conditions**
Clear Channel	40 Mbit/s	Fixed reception with full coverage, and portable reception with reduced coverage
Clear Channel	15 Mbit/s	Portable reception with full coverage
Clear Channel	5 Mbit/s	Mobile reception
Taboo Channel	20 Mbit/s	Fixed reception with reduced coverage, and very limited portable reception
Taboo Channel	10 Mbit/s	Fixed reception with full coverage, and portable reception with reduced coverage
Taboo Channel	4 Mbit/s	Portable reception with full coverage

These capacity figures are to be compared with the figure for a satellite channel of 45 Mbit/s. The term "full coverage" is here intended to imply the provision of a similar coverage as that currently available from PAL services from any given transmitter. The term "reduced coverage" is not yet precisely defined, since the necessary technical studies are not complete. The order of magnitude of reduction in population coverage for fixed reception in the "Taboo channel, 20 Mbit/s" case might be of the order of 20-30 per cent. The magnitude of coverage reduction in the context of portable reception is currently even less certain. As far as reception conditions are concerned, "mobile" implies reception in a car or train, "portable" implies reception from a fixed position but with a simple set-top or integrated aerial and "fixed" implies the use of a high quality roof-top aerial. (The concept of mobile reception is included, since this is an area being studied at present by the receiver industry. To our knowledge, however, there is very little interest among broadcasters in the development of a transmission system designed for this purpose).

5. By comparing the channel capacities given in the above table with the compression figures given earlier in paragraph 1, the following points can be highlighted:

- the provision of full studio HDTV quality (requiring a capacity of around 40 Mbit/s) probably needs the availability of clear channels if coverage is not to be substantially compromised;
- if coverage performance similar to PAL is required and only taboo channels are available, then these channels (10 Mbit/s) might carry one full studio-quality signal, two PAL-equivalent signals or perhaps six VHS-equivalent signals.

These conclusions are tentative since the field trials in the SPECTRE project (and in other projects in Europe) which are seeking to quantify these factors are not yet complete, but they give a broad indication of the limitations of terrestrial channels - especially when compared with the satellite case.

6. The other major technical issue for digital terrestrial television is channel availability. Unlike satellite, this is variable geographically across the UK. A computer study of digital terrestrial channel availability has been carried out in the SPECTRE project using planning assumptions appropriate to a modulation and transmission system capable of carrying a capacity of 10 Mbit/s. Only taboo channels were assumed since the planning considered only existing broadcast frequencies and took account of all existing (and planned) PAL transmissions. UHF channels 35 and 37 were not included in the study, but are the subject of a separate frequency planning exercise currently being undertaken on our behalf by NTL. The study considered digital transmissions from only the main transmitters in the UK. The results are summarised in the map reproduced on the next page. It can be seen that in some parts of the UK more than 20 digital channels might be available, while in others the availability is three channels or less. This latter case arises from the existing high concentration of relay transmitters in these areas which makes it difficult to introduce even low power digital services alongside the PAL transmission. If a threshold is set at a minimum of four available channels per transmitter, then the calculations suggest that while PAL transmissions continue around 80 per cent of the UK population could be covered digitally from the existing main transmitter sites. (The figure for a minimum of five available channels, rather than four, is almost the same). This compares with a figure for PAL coverage from these sites of approximately 90 per cent. The relay transmitters which provide the remaining 9 per cent or so for PAL were not included in this study. It is certainly the case that the identification of digital frequencies for the very large number of small relays currently in operation will not be feasible, although it is possible that use of some of the larger relays (covering, in aggregate, around 3-4 per cent of the UK population) might be able to enhance digital coverage. Further planning studies for these relays are now being commissioned.

7. The ITC intend to publish the full results of the SPECTRE frequency planning study, including detailed figures for each transmission site and a full explanation of the technical assumptions made, during the Summer. The document will be substantial in size, and so a charge will be made to cover printing and distribution costs. If you would like to be informed when this publication becomes available, please write separately to the ITC Publications Department.

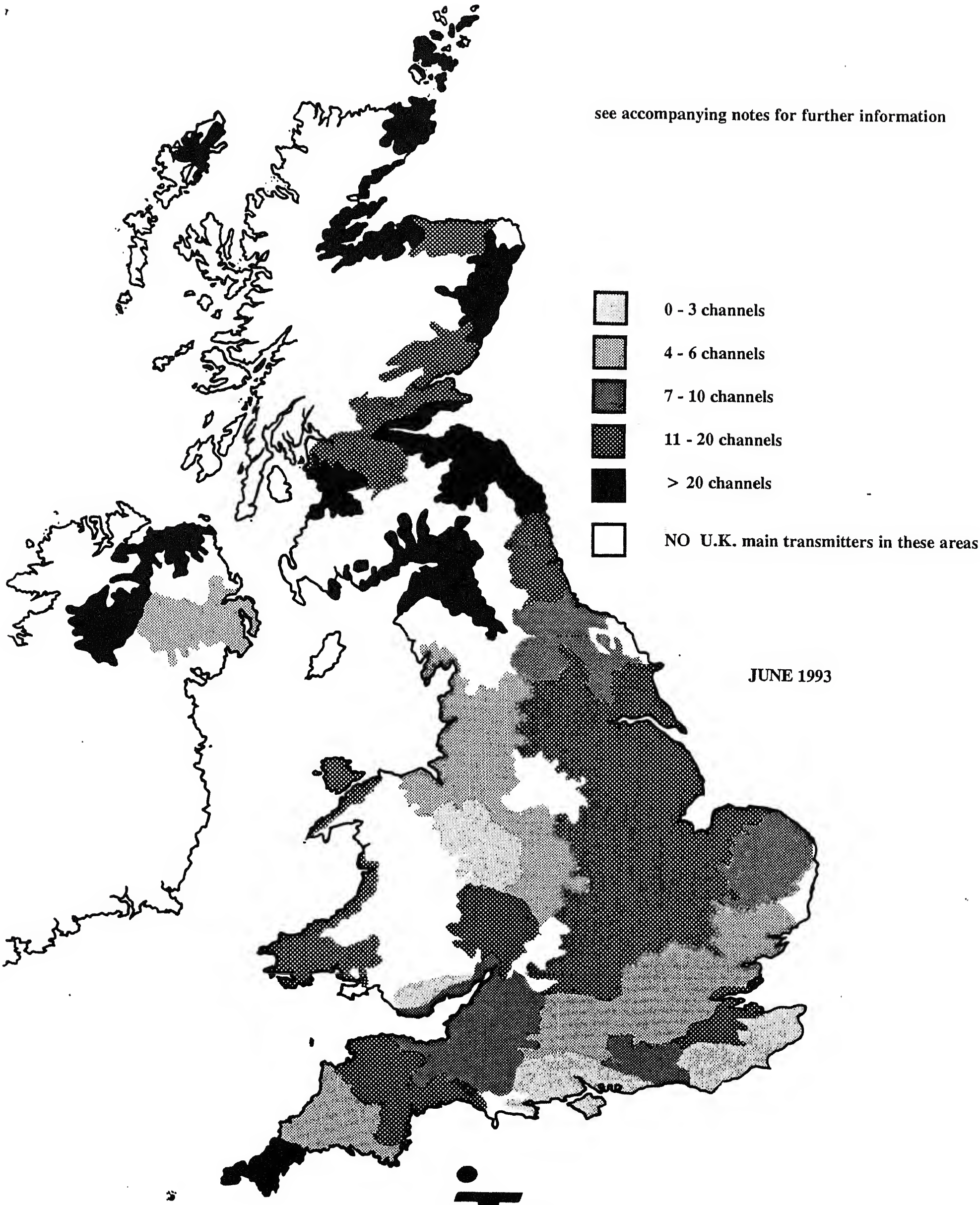
8. The coverage situation for digital terrestrial television would differ across Europe with Scandinavia, for example, being able to introduce more digital channels alongside its PAL transmissions than the UK, while France, Italy (and probably Germany) would fare less well than the UK. This makes it difficult to envisage a completely uniform introduction strategy for digital terrestrial television across Europe, although as much commonality as possible would be desirable, both for industrial policy reasons and in order to facilitate the necessary international frequency planning work.

9. The calculations of channel availability so far have assumed the continued existence of PAL transmissions. In the absence of analogue PAL services, however, clear channels (which have fewer technical restrictions, can operate with higher power, and can therefore carry a greater digital capacity or provide better coverage) would be available. If existing transmissions were removed also in neighbouring countries, and frequency planning were internationally co-ordinated, then these clear channels could be available) on a uniform basis throughout the UK. Furthermore, using some of the unique properties of an approach to digital modulation known as Orthogonal Frequency Division Multiplexing (OFDM) (which has been pioneered for radio and television broadcasting in Europe) adjacent transmitters carrying the same programme (and related) information could operate in principle on the same frequency - thus leading to a substantial improvement in spectrum efficiency. In the limiting case where each transmitter would carry identical information, this would mean that all 44 of the current broadcast frequency channel allocations could in theory be used everywhere for digital services. With each channel able to carry one full quality HDTV service or eight PAL-equivalent services, this means that as many as 350 PAL-equivalent programme services might be provided terrestrially. There remain technical issues to be resolved, however, about the practicality of such single frequency networks. The larger the transmitter spacing, the more sophisticated the OFDM system needs to be and there are likely to be practical receiver limitations. Also the need to carry regional programme variations will constrain the ability to operate on a single frequency network. Nevertheless it is clear that in the long-term a relatively large number of digital terrestrial programme services should be technically feasible provided that PAL transmissions (and ideally also existing transmissions in neighbouring countries) can be terminated. No detailed planning studies for this situation have yet been carried out, but the possible number of services with PAL-equivalent quality might be of the order of 100 or for HDTV it might be of the order of 10-15. This can be compared with the four services currently provided for the same amount of spectrum

using PAL.

10. It has been assumed in the discussion so far that digital transmissions would take place from the same sites as current analogue services. This would be cheaper than using new sites, it would enable similar coverage patterns to be achieved, and it would enable existing receiving aerials to be used in many cases. A limitation, however, is that the scope for local transmissions with the digital service would be similar to that available now with PAL transmissions. Nevertheless the multi-programme capabilities of digital television could be used if desired to provide a variety of different strands of local interest programming across the same transmission area.

Potential Terrestrial Digital Television Capacity



see accompanying notes for further information

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iTc

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Notes to the map showing potential digital terrestrial television capacity.

1. This map represents a theoretical maximum number of digital channels that could be transmitted from the main UHF television sites in the United Kingdom. Only frequency planning aspects have been considered. The practical feasibility of incorporating the transmitting antennas for additional digital channels on existing mast structures has not been assessed.

2. Some of the channels will have so few frequency planning restrictions (incoming and outgoing interference) on them that they will be able practically to duplicate existing terrestrial television coverage. Many others will have varying degrees of restrictions so that coverage will be less than that of existing services. A few channels will have highly restricted coverage areas but will none the less serve significant populations.

3. Blank areas on the map indicate areas which are not covered by signals from main transmitters in the UK, whether the signals are analogue or digital. Where there are significant populations involved it is invariably the case that relay stations provide coverage. The study upon which this map is based did not consider finding digital channels for relay stations.

4. There is one anomalous representation on the map. The area of South Wales which lies along the Bristol Channel can receive signals from the Mendip (Bristol) transmitter and is therefore shown to be in the 7 to 10 channel category. However, the main transmitter for South Wales, Wenvoe (Cardiff) falls in the 0 to 3 channel category, so both results are represented on the map.